Set 13: Hydrolysis

1. a) Neutral
   b) Basic
   c) Basic
   d) Acidic
   e) Basic
   f) Acidic

2. b) Basic: $PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$
   Proton acceptor

   c) Basic $HCO_2^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$
   Proton acceptor

   d) Acidic: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
   Proton donor

   e) Basic: $CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$
   Proton acceptor

   f) Acidic: $HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + + H_3O^+$
   Proton donor
   Also Al^{3+} is an acidic anion $[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(OH)(H_2O)_5]^{2+} + H^+$

3. (a) Ammonium nitrate, calcium hydrogenphosphate, potassium sulfate, and ammonium chloride.
   (b) The salts contain either an anion of a weak acid or the cation of a weak base.
   (c) Ammonium nitrate $NH_4^+(aq) + H_2O(\ell) \leftrightarrows NH_3(aq) + H_3O^+(aq)$
   calcium hydrogenphosphate $HPO_4^{2-}(aq) + H_2O(\ell) \leftrightarrows H_2PO_4^-(aq) + OH^-(aq)$
   and $H_2PO_4^-(aq) + H_2O(\ell) \leftrightarrows H_3PO_4(aq) + OH^-(aq)$
   potassium sulfate $SO_4^{2-}(aq) + H_2O(\ell) \leftrightarrows H_SO_4^-(aq) + OH^-(aq)$
   ammonium chloride $NH_4^+(aq) + H_2O(\ell) \leftrightarrows NH_3(aq) + H_3O^+(aq)$
   (d) These salts contain only ions derived from strong acids and strong bases so they do not react with water to produce the strong acid or strong base.

4. $H_2PO_4^-(aq) + H_2O(\ell) \leftrightarrows H_3PO_4(aq) + OH^-(aq)$

5. (a) Yes, it becomes basic.
   (b) $Na_2CO_3(aq) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$ and $CO_3^{2-}(aq) + H_2O(\ell) \leftrightarrows HCO_3^-(aq) + OH^-(aq)$

6. (a) $OH^-(aq) + CH_3COOH(aq) \rightleftarrows H_2O(\ell) + CH_3COO^-(aq)$
   (b) The solution would be basic.
   (c) $CH_3COO^-(aq) + H_2O(\ell) \rightleftarrows CH_3COOH(aq) + OH^-(aq)$

7. Yes as F^- is the anion of a weak acid. $F^-(aq) + H_2O(\ell) \rightleftarrows HF(aq) + OH^-(aq)$

8. The pH of a solution of ammonium ethanoate depends on the relative strength of the weak base ammonia and the weak acid ethanoic acid. This ultimately determines the relative extent of hydrolysis that the ammonium undergoes compared to the ethanoate ion. The hydrolysis process is represented by the equations:

$$NH_4^+(aq) + H_2O(\ell) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

and

$$CH_3COO^-(aq) + H_2O(\ell) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$$

If the weak base ammonia is weaker than the weak acid ethanoic acid ammonium ion will hydrolyse more than the ethanoate ion and so more H_3O^+ ions will be produced resulting in an acidic solution. If ,however, the ethanoic acid is weaker than the ammonia the reverse is true and the solution will be basic.

If the ionisation of the ethanoic acid and the ammonia is the same the degree of hydrolysis of the ethanoate and ammonium ions will be the same and equal numbers of H_3O^+ and OH^- will be produced so the solution will be neutral. As it turns out their ionisation constants are both close to 1.8×10^{-5} so the solution will be neutral.